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REMEDIAL ACTION PLAN
FUEL RELEASE FROM UNDERGROUND STORAGE TANKS
FORMER TIPPLE MOTORS
524 MAIN STREET
FERNDALE, CALIFORNIA
(HCDEH LOP# 12052)

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INTRODUCTION

This report presents Trans Tech Consultants (TTC) Remedial Action Plan (RAP) to remediate a release of gasoline from removed underground storage tanks (UST) at the former Tipple Motors, 524 Main Street, Ferndale, California (site). The purpose of this RAP is to present the technical approache to corrective action for the subject site. The information and technical approaches to corrective action presented in this report are based on our understanding of site conditions gained from previous subsurface investigations, and directives from the Humboldt County Department of Health Services, Division of Environmental Health (HCDEH).

BACKGROUND

Site Description

The site is located in a light commercial and retail area within the Ferndale City limits, as shown on the Site Location Map, Plate 1. Residential properties are present within 50 feet of the site. The site and improvements are shown on the Site Plan with Boring Locations, Plate 2. The residences and businesses in Ferndale are served by public utilities for drinking water supply and sewage disposal. The site is flat and currently contains a single-story structure housing an automotive repair facility and a service station. Two 4,000-gallon USTs in a common excavation presently supply gasoline for retail sale. Two 550-gallon USTs were previously closed in-place and are located adjacent to the structure.

Previous Site Activities

September 1978:

We understand that in September 1978, two 4,000-gallon gasoline USTs were installed at the site. Two 550-gallon gasoline USTs were abandoned in-place at the same time by filling them with pea gravel and topping them off with a concrete slurry. Soil samples were collected in June of 1988 to fulfill HCDEH tank closure requirements. Analysis of these samples detected total petroleum hydrocarbons (TPH) as gasoline at concentrations as high as 6,100 milligrams per kilogram (mg/Kg). In an April 19, 1993 letter, Mr. Jim Clarke of HCDEH requested a soil and groundwater investigation be implemented at the site.

November to December 1993:

In November and December 1993, TTC performed a preliminary site investigation which consisted of drilling seven soil borings (SB-1 through SB-7) and installing two groundwater monitoring wells (MW-1 and MW-2) in the vicinity of the abandoned USTs. Soil boring and well locations are shown on Plate 2. The results of our preliminary investigation were presented in a June 16, 1995 Summary Report. Soil and groundwater samples collected during the preliminary investigation were analyzed for TPH as gasoline, benzene, toluene, ethylbenzene, and xylenes (BTEX), and total lead. Based on the results of our preliminary investigation, it appeared that high concentrations of gasoline constituents were present in soil and ground water in the vicinity of the abandoned gasoline tanks and that the extent of gasoline constituents remained undefined in soil and shallow ground water.

July to August 1996:

In July and August of 1996, TTC performed additional investigation by drilling nine additional test borings (SB-8 through SB-17) and converting three of the borings to monitoring wells MW-3 through MW-5. The results of our investigation were summarized in a December 3, 1996 Summary Report.

On September 25 through 29, 1997, Haberstock Construction of Fortuna, California, removed the two active 4,000-gallon and two inactive 550-gallon USTs located on the site. During the excavation procedures the gasoline pump island, hydraulic auto hoist, and approximately 590 cubic yards of contaminated soil were removed from the vicinity of the former USTs. The results of the excavation activities and laboratory sample results were presented in our October 24, 1997, Summary Report. Excavation limits are shown on Plate 2.

October 1997:

On September 29 through October 1, 1997, Haberstock Construction backfilled the excavation with clean imported fill. Stabilization fabric was placed into the excavation at 8 feet below ground surface (BGS). TTC applied 630 pounds of Oxygen Release Compound (ORC) to the backfill material, placed from the bottom of the excavation to the top of the capillary fringe zone, estimated at about 4 feet BGS.

October 2002:

On October 7 and 8, 2002 TTC and Clear Heart Drilling of Santa Rosa, in order to further investigate and delineate the extent of the groundwater impact in the northwesterly, westerly, and southwesterly directions, advanced five soil borings and two monitoring wells at the locations shown on Plate 2. The soil borings were advanced to approximately 10-11 feet below ground surface (BGS) using 5-inch solid stem augers. Temporary screens were placed in the borings for the collection of grab water samples. The monitoring wells were advanced to approximately 15 feet BGS using 8" hollow stem augers. Our geologist observed the drilling procedures and obtained soil samples at maximum depth intervals of five feet, at pronounced changes in soil type, from zones of obvious contamination, and from just above free groundwater.

Two soil samples per boring were collected for laboratory chemical analysis using 2.0-inch inside diameter split spoon sampler lined with clean stainless steel sample tubes. The soils encountered were classified in accordance with the Unified Soil Classification System. In general, soils encountered consisted of brown clayey silt from just below the ground surface to approximately 3-4 feet BGS. The clayey silt is underlain to approximately 15 feet BGS, the maximum depth explored, by greyish, bluish, brownish, soft clay. Temporary well screen was placed in the borings to aid in the collection of grab water samples. Grab groundwater samples were collected from each boring and were submitted for laboratory chemical analysis.

Local Geology and Hydrogeology

Published geologic data reviewed indicates the site is underlain by estuarine deposits which consist of silty sands and clayey silts. Underlying the estuarine deposits is the Hookton Formation, consisting of weakly consolidated marine sands with minor pebbly beds and clay strata. Our test borings encountered estuarine deposits to the depths explored, consisting mainly of grey silty clay, with occasional interbeds of silt and clayey sand.

Local topography would suggest that the groundwater flow in the vicinity is to the northwest, toward Francis Creek, approximately 300 feet northwest of the site. However, groundwater elevation measurements collected during the three months following installation of monitoring wells MW-3 through MW-5, indicate that ground water at the site is at shallow depth, ranging from about 3.8 to 5.9 feet below ground surface (BGS), with the direction of flow generally to the east.

Results of Chemical Analysis

The laboratory analytical results of soil and groundwater samples collected during our previous investigations are presented below in units of mg/Kg or micrograms per kilogram (µg/Kg) for soil, and milligrams per liter (mg/L) or micrograms per liter (µg/L) for water. Soil and groundwater samples were analyzed for TPH as gasoline, for BTEX, and total lead.

Soil Samples

Boring	Depth in Feet	TPH as Gasoline	B	T	E	X	Total Lead
		mg/Kg	µg/Kg				mg/Kg
SB-1	5.5	1.2	73	5.2	20	15	90
SB-2	5.5	1,400	<250	<250	13,000	<250	12
SB-3	4.0	570	5,200	1,100	7,400	32,000	10
SB-4	4.0	170	<250	<250	1,400	1,700	11
SB-5	7.0	3.1	980	4.5	25	25	4.3
SB-6	4.0	4.5	<2.5	<2.5	<2.5	<2.5	72
SB-7	6.5	600	1,500	<500	3,500	2,500	5.0
MW-1	7.5	<1	<2.5	<2.5	<2.5	<2.5	4.6
MW-2	7.0	3.4	650	20	130	190	.7

Boring	Depth in Feet	TPH as Gasoline	B	T	E	X	Total Lead
		mg/Kg	µg/Kg				mg/Kg
SB-8	11.5	**1,400**	**7,800**	**4,800**	**35,000**	**16,000**	**10**
SB-9	4.5	**420**	<250	**390**	<250	<250	**8.6**
SB-9	15.5	<1.0	<2.5	<2.5	<2.5	<2.5	**5.6**
SB-10	12.0	**1.8**	**200**	**9.4**	**15**	**20**	**6.4**
SB-11	12.0	**1.6**	**65**	**5.4**	**16**	**9.2**	**6.7**
SB-13	7.5	**1.0**	**87**	<2.5	**5.4**	**6.0**	**5.1**
SB-14	6.5	**60**	**56**	<2.5	**72**	**61**	**6.2**
SB-17	6.0	<1.0	<2.5	<2.5	<2.5	<2.5	**5.8**

< = Not detected above the indicated laboratory reporting limit.

Groundwater Samples

Date	Monitoring Well	TPH as Gasoline	B	T	E	X	Total Lead
		mg/L	µg/L				mg/L
12/27/93	MW-1	**0.07**	<0.5	<0.5	<0.5	<0.5	<0.002
	MW-2	**6.3**	**1,100**	**78**	**16**	**610**	**0.030**
07/10/96	SB-8	**80**	**5,500**	**630**	**3,400**	**1,200**	NA
	SB-9	**16**	**790**	**52**	**280**	**190**	NA
	SB-10	**0.78**	**99**	**1.9**	**2.0**	**3.8**	NA
	SB-11	**0.60**	**19**	**2.0**	**2.2**	**2.2**	NA
	SB-12	<0.05	<0.50	<0.50	<0.50	<0.50	NA
	SB-13	**2.6**	**330**	**15**	**24**	**15**	NA
08/30/96	MW-1	**0.06**	<0.5	<0.5	<0.5	<0.5	**0.012**
	MW-2	**11**	**3,900**	**200**	**550**	**1,100**	**0.012**
	MW-3	<0.05	<0.5	<0.5	<0.5	<0.5	<0.002
	MW-4	**0.12**	**4.9**	<0.5	**0.6**	**0.7**	**0.004**
	MW-5	<0.05	<0.5	<0.5	<0.5	<0.5	<0.002

< = Not detected above the indicated laboratory reporting limit.
NA = Not analyzed.

Table 2 -Soil Sample Results October 2002 Investigation

Date	Sample ID	TPH-gasoline	TPH-diesel	B	T	E	X	MTBE
		mg/Kg						
10/07/02	MW-6-4'	<1.0	<5.0	<0.005	<0.005	<0.005	<0.015	<0.025
	MW-6-9'	<1.0	<5.0	<0.002	<0.002	<0.002	**3.9**	<0.002*
	SB-18-5'	<1.0	<5.0	<0.005	<0.005	<0.005	<0.015	<0.025
	SB-18-9'	<1.0	<5.0	<0.002	<0.002	<0.002	**3.8**	<0.002
	SB-19-4'	<1.0	<5.0	<0.002	<0.002	<0.002	**3.0**	<0.002
	SB-19-9'	<1.0	<5.0	<0.005	<0.005	<0.005	<0.015	<0.025
10/08/02	MW-7-4'	<1.0	<5.0	<0.005	<0.005	<0.005	<0.015	<0.025
	MW-7-9'	<1.0	<5.0	<0.002	<0.002	<0.002	**2.8**	<0.002
	SB-20-3.5'	<1.0	<5.0	<0.005	<0.005	<0.005	<0.015	<0.025
	SB-20-7'	<1.0	<5.0	<0.002	<0.002	<0.002	**3.7**	**12***
	SB-21-4'	<1.0	<5.0	<0.002	<0.002	<0.002	**3.9**	<0.002
	SB-21-6'	<1.0	<5.0	<0.005	<0.005	<0.005	<0.015	<0.025
	SB-22-4'	<1.0	<5.0	<0.002	<0.002	<0.002	**3.7**	<0.002
	SB-22-9'	<1.0	<5.0	<0.005	<0.005	<0.005	<0.015	<0.025

* Additional oxygenated fuel additives were detected above the laboratory detection limit, see laboratory report for details.

Table 3 - Groundwater Sample Results October 2002 Investigation

Date	Sample ID	TPH-gasoline	TPH-diesel	B	T	E	X	MTBE	1,2-dichloroethane
		ug/L							
10/07/02	SB-18	<50	<50	<1.0	<1.0	<1.0	<1.0	<1.0	NA
	SB-19	<50	<50	<1.0	<1.0	<1.0	<1.0	<1.0	NA
10/08/02	SB-20	**78**	<50	<1.0	<1.0	<1.0	<1.0	**64***	NA
	SB-21	**88**	<50	<1.0	<1.0	<1.0	<1.0	**2.3**	NA
	SB-22	<50	<50	<1.0	<1.0	<1.0	**1.0**	<1.0	NA
12/02/02	MW-1	<50	<65	<0.30	<0.30	<0.50	<0.50	**38***	<50
	MW-2	**29,000**	**1,600**	**6,000**	**110**	**960**	**1,200**	<50*	**99**
	MW-3	<50	<65	<0.30	<0.30	<0.50	<0.50	<0.50*	<0.50
	MW-4	**350**	**320**	**25**	**0.73**	**1.9**	**1.0**	**45***	**1.0**
	MW-5	**190**	**320**	**0.35**	<0.30	**0.58**	<0.50	<0.50*	<0.50
	MW-6	<50	<65	<0.30	<0.30	<0.50	<0.50	<0.50*	<0.50
	MW-7	<50	<100	<0.30	<0.30	<0.50	<0.50	**0.61**	<0.50

* Additional oxygenated fuel additives were detected above the laboratory detection limit, see laboratory report for details.

Most recently, On October 30, 2004, TTC staff were onsite to advance one soil boring (SB-23) for the purpose of delineating soil and groundwater impact under the existing structure. The approximate location of SB-23 is shown on Plate 2.One groundwater sample and three soil samples collected from boring SB-23 were submitted for laboratory chemical analysis. The samples were analyzed for TPH as gasoline(g), TPH as diesel(d), BTEX, and the five oxygenated fuel additives including MtBE by EPA Test Methods 8260/8015. One soil sample was collected and preserved using EPA 5035 protocols. The analytical results of the soil and groundwater samples collected are tabulated in units of milligrams per kilogram (mg/kg) for soil and micrograms per liter (µg/L) for groundwater

Soil Sample Results

Date	Sample ID	TPH-g	TPH-d	B	T	E	X	MtBE
		-------------------mg/kg-------------------						
10/30/04	SB-23-4.5	**3,600**	**410***	<43	<43	**76**	**430**	<43
	SB-23-7	**52**	**3.9**	**1.7**	<0.87	**1.2**	**4.8**	<0.87
	SB-23-8	**3.0**	<1.0	<0.0031	<0.0031	<0.0031	<0.0031	<0.0031**

< = not detected at or above the indicated laboratory detection limit.
* = results in the diesel organics range are primarily due to overlap from a gasoline range product.
** = di-isopropyl ether detected at 0.0035 mg/kg.

Groundwater Sample Results

Date	Sample ID	TPH-g	TPH-d	B	T	E	X	MtBE
		-------------------µg/L-------------------						
10/30/04	SB-23	**28,000**	**3,500***	**2,100**	**390**	**1,500**	**3,500**	<50

< = not detected at or above the indicated laboratory detection limit.
* = results in the diesel organics range are primarily due to overlap from a gasoline range product

Periodic monitoring events have been performed. The most recent monitoring event was performed on March 16, 2005. The analytical results in addition to a summary of monitoring data were presented in our QMR, dated April 11, 2005.

REMEDIAL OPTION EVALUATION

Approaches to site remediation can be divided into two broad categories: in-situ (in ground) methods which remove the contaminants from the impacted medium (soil and ground water) by physical, chemical, or biological means without removing the medium itself (such as vapor extraction, air/ozone sparging, and both passive and enhanced biodegradation), and ex-situ methods which address impacted soil or ground water by physically removing and/or treating or disposing of the contaminated medium (such as soil excavation or groundwater pump-and-treat). Often, a combination of the two approaches can provide the most cost-effective means to address soil and ground water impacted by petroleum hydrocarbons at a site.

The advantages of in-situ systems are the relatively minor intrusion to normal property use, simultaneous treatment of both soil and ground water within the zone of treatment, and the ability to treat impacted soil and ground water beyond the immediate footprint of the system, possibly including areas beneath existing structures. The main disadvantages of these systems are the time required to effectively remediate the site (typically ranging from six months to two years) and the need to perform adequate pilot tests to properly design the system. Air quality permitting is typically required for the SVE portion of the system due to the extraction of volatile compounds.

The feasibility of operating these systems efficiently is dependent in large part on the type and characteristics of the soils to be treated and the depth to shallow ground water. Soils with lower permeabilities, such as the silts and clays underlying this site, inhibit the processes associated with these systems by restricting the movement of soil gases. Although closely spaced injection and extraction points may mitigate low soil permeabilities, preferential pathways to the surface in the wellbore may undermine system effectiveness.

Proposed Remediation Action

TECHNICAL WORKPLAN

In this Section a technical proposal for site remediation is presented.

Basis For Design

The Tipple Motors site is impacted with both diesel and gasoline contamination, although gasoline contamination predominates. A remedial technique which is applicable to both types of contamination is preferable. The two remedial techniques applicable to both gasoline and diesel contamination which were evaluated for implementation at this site are:

- Dual phase extraction
- In-situ oxidation/oxygenation

The applicability of each technique for remediation of the Tipple Motors site is described in the following paragraphs.

Dual Phase Extraction

Dual phase extraction is a process where soil vapor and groundwater are simultaneously extracted from the sub-surface. Remediation occurs due to the direct removal of contaminant mass and through the introduction of oxygen into the subsurface (air is drawn into the subsurface to replace extracted soil vapor).

By controlling the groundwater elevation, dual phase extraction is more efficient than soil vapor extraction alone. Groundwater extraction prevents mounding. It is advantageous to prevent mounding as it results in some of the contaminant mass becoming submerged where it can not be subjected to vapor extraction.

The mass removal of contamination via groundwater extraction is small relative to vapor extraction, however the proportion of gasoline to diesel removal is approximately equal. In the vapor phase, the proportion of gasoline contamination removed as compared to diesel is much greater, due to gasolines higher volatility.

A disadvantage to the dual phase extraction approach is the necessity to treat and dispose of two waste streams; soil vapor and groundwater. Groundwater, in particular, can be difficult to dispose of, treated or not. At Tipple Motors it is feasible to dispose of treated groundwater to the City of Ferndale sanitary sewer system. Also, it is feasible to obtain a permit for the atmospheric discharge of treated soil vapor.

The biggest problem with applying dual phase extraction as a remedial approach at Tipple Motor's is the low soil permeability. Both the soil vapor and groundwater yields are projected to be low. Low yield translates to a longer remedial duration and higher costs.

In-situ Oxidation/ Bioremediation

Petroleum hydrocarbon based contamination can be oxidized in the subsurface by a variety of commercially available compounds. Oxidizing agents have the dual benefit of oxygenating the subsurface which promotes aerobic biodegredation. In-situ remediation also has the advantage of generating no waste streams for disposal. Consequently, permitting is simpler.

The principal challenge to applying in-situ oxidation at the Tipple Motor's site is effective delivery of the oxidizing agent to the contaminant plume. Since a significant portion of the contaminant mass has migrated under surface structures, innovative means for injecting the oxidizing agents must be employed.

The list of remedial compounds which could be injected into the Tipple Motor's plume includes: hydrogen peroxide, potassium permanganate, ozone, oxygen release compound, industrial grade oxygen and air. The underground delivery system is basically the same regardless of the product used. Quite possibly, an oxidizing agent such as hydrogen peroxide may initially be used and then an oxygenation product like industrial grade oxygen used later as a polishing step.

The North Coast Regional Water Board does not require a special permit for the injection of gaseous materials such as ozone, oxygen or air into groundwater. Liquid materials, on the other hand, such as oxygen release compound, Fenton's reagent, hydrogen peroxide, etc., do require an authorization issued under a General Order for Waste Disposal.

Summary

The advantages and disadvantages of dual phase extraction vs. in-situ oxidation as the remedial approach for Tipple Motors are compared in the Table below.

REMEDIAL APPROACH	ADVANTAGES	DISADVANTAGES
Dual Phase Extraction	• Rapid Remediation • Direct Removal and Measurement of Contaminant Mass	• Two Waste Streams • Permitting • Considerable O&m • Obstructing Surface Structures Impede Installation of Extraction Points
In-situ Oxidation/ Bio-Remediation	• No Waste Streams • Simple O&m • Low Permeable Soils Less a Problem • Permitting	• Slower Remediation • Delivery System Hard to Install • Difficult to Measures Effectiveness

Both remedial approaches; dual phase extraction and in-situ oxidation/bioremediation are applicable to the Tipple Motors site. Each has advantages and disadvantages. However, because of the problems associated with installing effective extraction points under the existing surface structures and the low soil permeability, in-situ oxidation is selected as the preferred alternative.

Remedial Design

Major components of the Tipple Motors remedial design include:

- Injection line installation
- Establish equipment compound

Injection Line Installation

It is proposed to delivery oxidizing and oxygenating compounds to the contaminant plume via horizontal injection lines. The proposed injection line layout is indicated on the Site Plan, Plate R-1. Injection lines will be installed utilizing horizontal borings or a trench.

A cross section depicting the proposed trench cross section is shown on Plate R-2. Any contaminated soil excavated in the installation process will be removed from the site for proper disposal. Only clean soil will be imported for backfill purposes.

Trenches will be excavated to approximately 11 feet BGS. Three inches of 3/8 inch washed pea gravel will be placed on the trench bottom. A 1.25 inch diameter schedule 40 PVC pipe will be laid on the pea gravel and then bedded with an additional 8 inches of pea gravel. Geotextile fabric will be placed on the pea gravel bedding prior to backfill with compacted native and/or imported soil.

Injection lines will be installed under buildings utilizing horizontal boring techniques. A pit will be excavated at the rear (east) of the property as indicated on Figure ?. In order to keep the pit dry a dewatering pump will be placed in the pit. Groundwater removed from the pit will be filtered to remove sediment, processed through activated carbon to remove organics and then discharged to the City of Ferndale sanitary system under a temporary permit.

A total of up to 12 horizontal borings, each approximately 90 feet in length, will be advanced. For each boring, a sacraficial drill bit will be attached to 1.25 inch diameter galvanized steel pipe. The drill string will be advanced throughout the length of the boring and then abandoned in place. A series of holes (9/16 diameter on 6 inch centers) will be pre-drilled in the drill pipe which will allow the drill pipe to function as the injection line.

Sealing the horizontal boring is critical to proper operation. A two step process will be used to ensure an effective seal. Each boring will first be sealed by sliding a packing disk up the drill rod at least two feet. A second packing disk equipped with a grout fitting will then be positioned at the front of the boring. The space between the packing disks will be filled with a five percent bentonite portland cement grout. A riser will be attached to the grout fitting to maintain hydrostatic pressure on the grout as it cures.

Secondly, each injection line will be brought to the ground surface in a four inch diameter PVC conduit. Clean soil will be compacted around the PVC risers to backfill the drill pit. Bentonite cement grout will then be placed into the annulus as a seal between the conduit and the injection line.

All four injection lines will be undergrounded independently to the back of the tire shop. The lines will be brought up and through the back wall into the tire shop to the equipment compound location.

Oxidizer/Oxygenating Compound Injection

The injection system described above is capable of effectively delivering either gaseous or liquid products into the sub-surface. Gaseous products could include air, ozone or industrial grade O_2. Liquid products could include oxygen release compounds, hydrogen peroxide and potassium permanganate.

Air injection would be accomplished by installing an electrically driven positive displacement, oil free, air pump. Industrial grade oxygen is delivered in pressurized cylinders, consequently injection is simply a matter of connecting the cylinder to the distribution lines through a pressure regulator. Equipment for air and/or oxygen injection can be located within the tire shop and operate utilizing the existing electrical service.

Ozone injection would be accomplished by installing an ozone generation system behind the tire shop in an outdoor, fenced, equipment compound. A separate dedicated electric service would be established to operate the system.

Liquid oxidizing/oxygenating products would be injected utilizing a positive displacement metering (dosing) pump. A holding tank would be placed behind the tire shop for storage and/or mixing of injection liquids.

OPERATION AND MAINTENANCE

It is proposed to conduct a test program with the objective of identifying the most effective injection compound and dosing rate.

Injection Test

Carbon dioxide is formed when a petroleum hydrocarbon compound is chemically oxidized. Carbon dioxide is also a byproduct of microbial decomposition. More CO_2 is formed in an aerobic microbial environment than in an anaerobic environment. Therefore, careful and systematic measurement of carbon dioxide concentrations before and after injection of different oxidizing agents will provide a measure of the contaminant mass oxidized.

Prior to initiating any remedial activities, the background CO_2 concentration will be measured in soil vapor withdrawn from existing monitoring well MW-2 with a 12 volt vacuum pump . The CO_2 concentration will be measured in the field utilizing a portable analyzer. A representative soil vapor sample will also be collected in a Summa cannister for laboratory analysis.

For the test, oxidizing agents will be injected into line nearest MW-2 and the resultant increase in CO_2 concentration measured at MW-2. In order to obtain comparable results, only one oxidizing agent per week will be tested. Environmental conditions will be allowed to return to background levels between test runs.

Because it is logistically complicated to perform a test run with ozone, other oxidizing agents will be tested first to verify that the distribution system is effective. If it appears that the injection system is functioning as planned, arrangements for an ozone test run will be made.

Upon determination of the optimum oxidizing/oxygenation agent to be employed, a second test program will be conducted to determine the most effective application rate. The second test program will be performed in conjunction with system start-up activities.

Operation

Injection of oxidizing/oxygenation compounds into the distribution grid proposed for Tipple Motors is relatively straightforward, the biggest operational challenge is assuring a constant supply of oxidizer material. The exceptions are ozone, which is manufactured on-site and air, which is supplied by the atmosphere.

An ozone generation system is relatively complicated and requires operator attention at least every 3-4 days for reliable operation. Ozone has impressive remedial capabilities, however, and has the potential to clean up the site to closure standards in a short period of time.

An air injection system requires the least amount of operator interaction of all the systems considered, however it also has the least remedial effectiveness.

For those oxidizing/oxygenation compounds which must delivered to the site, a delivery schedule will be developed once the application rates have been determined.

Monitoring

In-situ remediation systems inherently pose the problem of measuring remedial effectiveness. As described below, measurement of carbon dioxide concentrations can provide some measure of volatile oxidation, however oxidation of naturally occurring organic material can complicate that analysis.

It is proposed to measure CO_2 concentrations in vapor samples collected from existing monitoring wells MW-2, MW-4 and MW-5 on a monthly basis. It is anticipated that CO_2 concentrations will increase for a period of time as organic material is oxidized and aerobic microbial activity increases and will then decrease as organic material in the subsurface is depleted.

Dissolved oxygen concentrations will also be measured on a monthly basis in all seven groundwater monitoring wells. Detection of measurable dissolved oxygen within the contaminant plume is an indicator of successful groundwater remediation.

It is proposed to continue quarterly groundwater monitoring. Because groundwater contaminant concentrations at Tipple Motors exhibit a marked seasonal trend, comparison of long term trends on a quarterly basis is the most accurate method of monitoring the improvement in groundwater quality.

Reporting

It is proposed to prepare and submit monthly remedial status reports to the Humboldt County Division of Environmental Health. Each status report will include a description of operational run time, quantities of oxidizing/oxygenation products injected, results of CO_2 and DO monitoring and an estimate of contaminant mass remediated. Every third status report will be incorporated into the quarterly groundwater monitoring report.

It is proposed to install a series of horizontal injection/extraction lines throughout the impacted area, under the buildings. The lines will be used to inject air or other oxygen bearing compounds and to extract contaminated soil vapor or groundwater.

Injection/Extraction Line Installation

The drill rig will be positioned in an approximately 3 foot deep, 20 foot wide trench line dug parallel with the north easterly exterior wall of the Tipple Motors Building, shown on Plate .

The depth of the horizontal shaft will vary from approximately 4.5 feet to approximately 11 feet below grade. The trajectory will be guided with a Rotary-steerable system drilling tools that will allow the well trajectory, inclination and azimuth, to be actively guided while rotating the drill bit. A pilot test will be performed to first assess the difficulty in dewatering, if necessary the trench line. Based on data collected during the pilot test program the configuration of extraction lines illustrated on Plate R-1 should provide an overlapping radius of influence for effective remedial measures.

Two layers of piping will be installed within the impacted area. A shallow set of piping at 4.5 to 6 feet BG will be installed for soil vapor extraction only. A deeper set of piping, set at 9 to 11 feet BG will be installed for injection or extraction.

Both sets of remediation piping will be bedded in 3/8" pea gravel. The installation will be finished with compacted fill soil and concrete pavement.

Each horizontal extraction/injection line will be connected to an individual riser brought to the ground surface. Each riser will be connected to individual pipes running at ground surface into the remediation equipment compound.

Equipment Compound

A secure equipment compound will be utilized to enclose all remediation equipment and supplies. It is proposed to site the remedial equipment compound within the southerly shop/storage area of the Tipple Motors Building, see Plate

Remediation Equipment

Both pressure injection and vacuum extraction capabilities will be provided at the equipment compound. Both are described in the following subsections.

Injection

The distribution system is capable of effectively delivering either gaseous or liquid products into the subsurface. Gaseous products could include air, ozone or industrial grade O_2. Liquid products could include hydrogen peroxide.

Air injection would be accomplished by installing an electrically driven positive displacement air pump. Industrial grade oxygen is delivered in pressurized cylinders; consequently injection is simply a matter of connecting the cylinder to the distribution lines through a pressure regulator. Ozone is typically injected into the subsurface by a rotary vane pump. Liquid products would be injected utilizing a positive displacement metering (dosing) pump.

Extraction

Potential extraction activities include dual phase (soil vapor and groundwater combined) or single phase (soil vapor or groundwater individually) extraction.

Dual phase extraction would occur where an extraction line is partially in groundwater or is very close to the capillary fringe. Utilizing vacuum as a driving force, the aspirated groundwater/vapor flow is extracted from the ground into a separation tank. The liquid phase is pumped from the bottom of the separation tank either directly to treatment or into a holding tank. The vapor phase passes from the top of the separation tank to treatment and then atmospheric discharge.

Where an extraction line is completely immersed, groundwater can be extracted utilizing vacuum as a driving force. The flow is directed into a vacuum tank containing a pump, which transfers the flow to treatment or a holding tank.

Soil vapor alone is extracted from lines completely within the vadose zone. Soil vapor extraction is accomplished by connecting the extraction line to a positive displacement vacuum pump.

Treatment

In this Section proposed methods for treating contaminated soil vapor and groundwater are presented.

Contaminated Vapor Abatement

Two alternatives are considered for soil vapor treatment: Thermal oxidation and activated carbon adsorption. Both technologies are applicable at the Vintage II site based on technical and regulatory considerations. The deciding factor is cost. Thermal oxidation is more economical as the flow rate and volatile loading increases. Activated carbon adsorption is more economical if the volatile extraction rate is low.

It is anticipated that thermal oxidation will be more economical in the early stages of remediation. At some point, volatile loading will decline to a level where activated carbon is more economical.

It is proposed to utilize activated carbon for soil vapor treatment during the start-up phase of the interim remedial program. Based on flow rate and volatile loading data collected during start-up, a decision to specify and install thermal oxidation capability will be made.

Groundwater Treatment

It is not proposed to extract groundwater from the site for purposes of remediation (pump and treat). Groundwater may be extracted coincidentally with soil vapor or may be extracted for purposes of hydraulic control. In either instance, the objective is to extract the minimum amount of groundwater possible.

Start-Up

It is proposed to conduct a start-up program to collect data for specification of remedial action equipment. The primary objectives of the start-up program are to measure soil vapor extraction rates, groundwater extraction rates and volatile loading rates.

A skid mounted, 200 SCFM, positive displacement SVE package will be installed at the Vintage II site for the start-up program. Vacuum will be applied to individual extraction lines and to individual extraction grids in increments of 3" Hg. During each test run stabilized vapor and/or groundwater extraction rates will be measured. Volatile loadings will be measured in the field utilizing a handheld PID. Selected vapor and groundwater samples will be collected for laboratory analysis.

Data collection specifics include:

Vapor Flow Rate: Vapor flow rate will be measured utilizing a Dwyer Instruments Series 471 thermo-anemometer. The anemometer probe measures flow velocity and temperature within a conduit. Flow rate is calculated based on the known pipe ID.

Volatile Loading: Volatile concentrations will be measured in the field utilizing a Mainer 2000 handheld PID. In order to compensate for flow rate, vapor samples will be pumped into a medlar bag for PID analysis. In accordance with the sampling schedule, vapor samples will be collected in evacuated summa canisters for laboratory analysis.

Wellhead Vacuum: The induced vacuum at the extraction point will be measured on a liquid filled vacuum gauge mounted on the vacuum manifold.

Vacuum Radius of Influence: Induced vacuum in other extraction lines and grids will be periodically measured during each test run.

Depth to Groundwater (DTG): Depth to groundwater will be periodically measured in existing groundwater monitoring wells during each test run to measure hydroponic response to extraction activities.

<u>Intrinsic Biodegradation</u>

Additional oxygen can accelerate microbial growth and activity beyond natural degradation rates. An in-situ approach is to increase the concentration of dissolved oxygen (DO) in the ground water and increase the oxygen content in the vadose-zone pore gases.

Due to low soil permeability, the delineation of the plume in the down gradient direction (see sampling data for wells MW-3 and MW-6) is likely due to intrinsic contaminant biodegradation and not due to dilution or dispersion. For the October 2001 monitoring period, ground water samples from wells MW-1 through MW-5 were analyzed in the laboratory for indicators of aerobic and anaerobic biologic activity (see the Dec 20, 2001 QMR by TTC).

Biologic indicators analyzed for included Total Alkalinity, pH, Free CO2, Nitrate, Sulfate, Manganese, Dissolved Oxygen (DO), Ferrous Iron, and Oxidation Reduction Potential. Of these indicators, DO is most useful in evaluating aerobic activity. From the EPA's NATURAL ATTENUATION STUDY IN WISCONSIN AND ILLINOIS, "The best evidence that natural attenuation was appropriate and sufficient at these sites and that biodegradation was occurring was provided by an evaluation of the difference in DO levels between impacted and background wells, the change in the concentration of chemicals of concern over time, decrease in the concentration of chemical of concern along the ground water direction, and the location of the plume edge relative to receptors."

The most impacted Well MW-2 showed a DO concentration of 1.6 mg/l on October 16, 2001. The DO concentrations in the remaining less-impacted wells ranged from 6.0-6.9 mg/l, indicating that aerobic biologic degradation is occurring in areas of impact. Subsequest sampling should be performed to verify the results.

A ground water sampling and analysis program to better quantify the biological process is recommended as part of an intrinsic biodegradation program. The appropriate analytical methods are presented in the Ground Water Monitoring section below.

<u>Monitored Natural Attenuation</u>

Hydrocarbon consuming aerobic microbes are present in the natural environment and can be found in the atmospheric air, surface and ground waters, and soils. Oxygen is often the limiting factor in aerobic biodegradation of hydrocarbon compounds in the subsurface. Moisture and nutrients, such as phosphorus and nitrogen, are generally present in sufficient quantities. Oxygen, however, is rapidly consumed by the microbes, which thrive in an oxygen rich environment. Anaerobic biodegradation can also occur in subsurface soils, but significantly, slower kinetics are associated with this process.

Additional oxygen can accelerate microbial growth and activity beyond natural degradation rates. An in-situ approach is to increase the concentration of dissolved oxygen (DO) in the ground water and increase the oxygen content in the vadose-zone pore gases.

Due to low soil permeability, and the delineation of the plume in the down gradient direction (see sampling data for wells MW-4 and MW-7), the declining trend demonstrated above is likely due to intrinsic contaminant biodegradation and not due to dilution or dispersion. Analytical methods are available to determine the whether the biological processes at work are aerobic or anaerobic, or a combination of both.

A ground water sampling and analysis program to better quantify the biological process is recommended as part of an intrinsic biodegradation program. The appropriate analytical methods are presented in the Ground Water Monitoring section below.

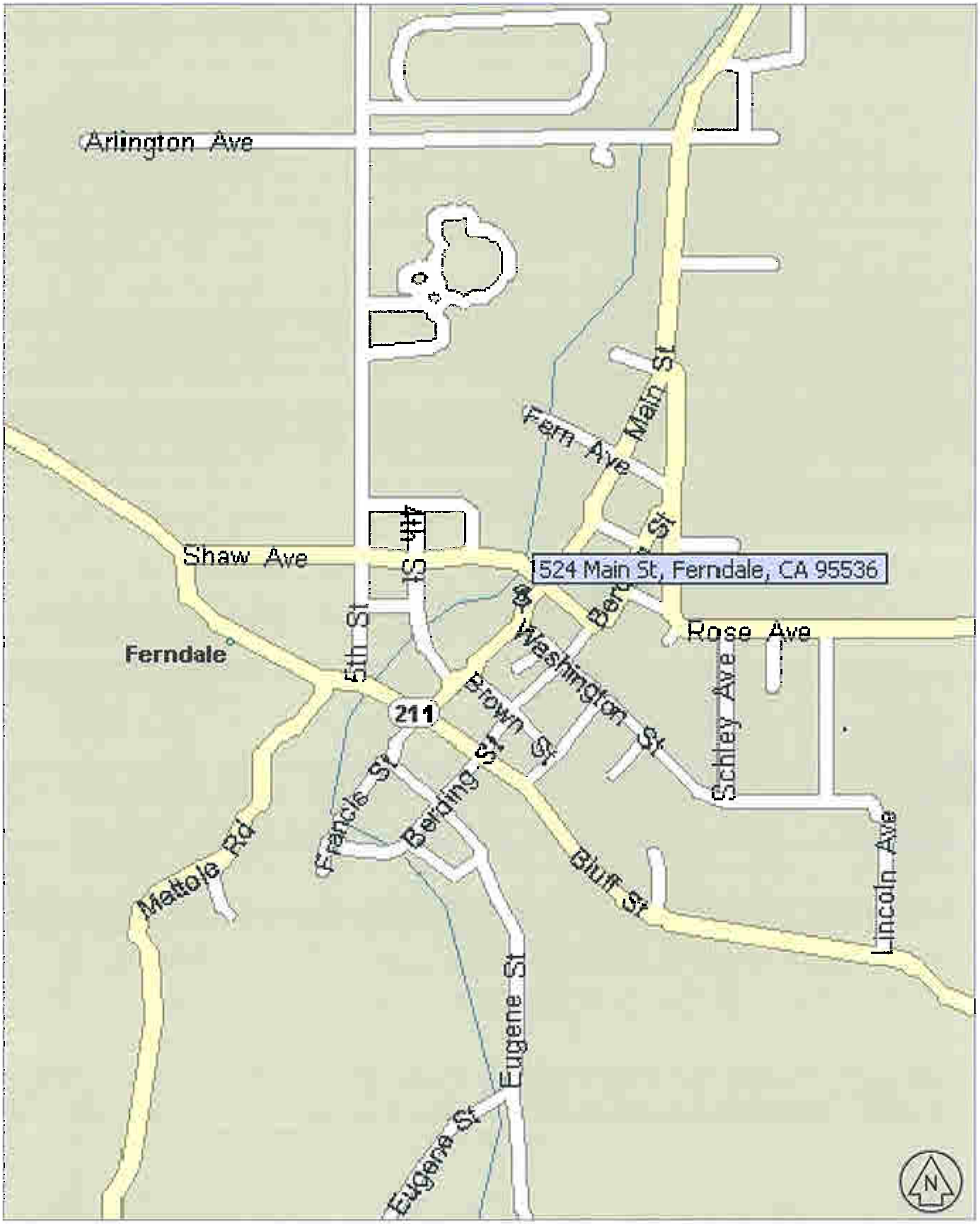
Ground Water Monitoring

We recommend two quarters of ground water monitoring beyond the most recent monitoring event that occurred in July 2004. During these monitoring events, we recommend that select wells be analyzed by the following methods for biologic activity indicators:

- Nitrate by EPA Method 300.0
- Oxidation/Reduction Potential
- Total and Ferric Iron by EPA Method 200.7
- Ferrous Iron using Hach Model 8146/1.19/0 by Phenanthroline Method
- Alkalinity by SM 2320B
- Dissolved oxygen (DO) and methane
- Bacteria enumeration for aerobic petroleum hydrocarbon degraders (plate counts) by method SM9215A/9215B modified

Water samples from these wells would also be analyzed for TPH-g, BTEX, and VOC's using EPA Test Methods 8020/8015/8260.

During the month following the completion of a sampling event, we would prepare a quarterly report for your review and, with your approval, for submittal. Each report will contain tabulations of the water level data, calculated ground water gradients, ground water sampling results for hydrocarbons and biologic indicators, water elevation contour maps, dissolved concentration versus time plots for impacted wells and a discussion of the relative trends observed.



TRANS TECH CONSULTANTS

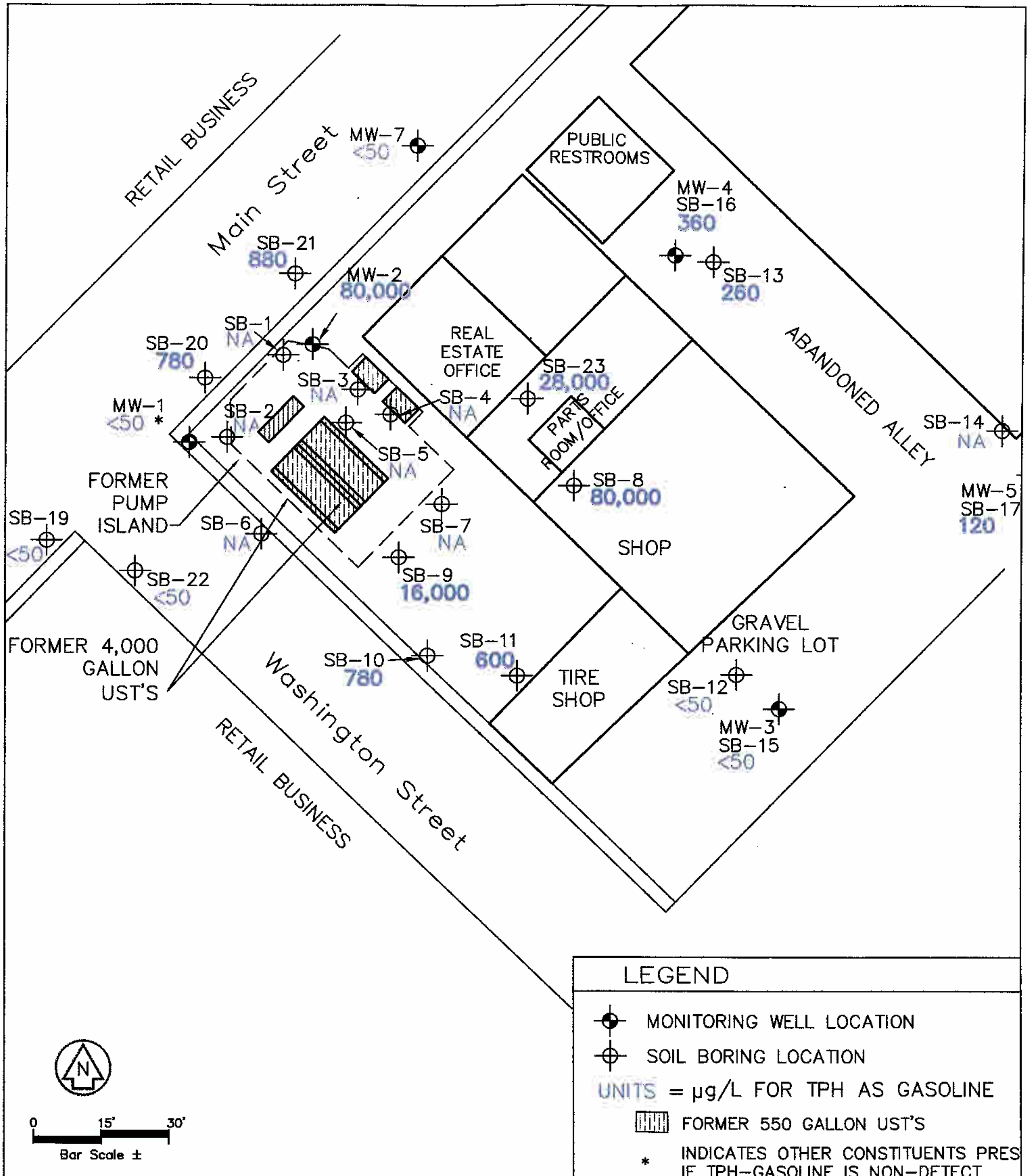
930 SHILOH RD., BLDG 44, SUITE J
WINDSOR, CA 95492
PHONE: 707-575-8622 FAX: 707-837-7334

SITE LOCATION MAP

TIPPLE MOTORS
524 MAIN STREET
FERNDALE, CALIFORNIA

PLATE: 1

DRAWN BY:	DWG NAME:	APPR. BY:	JOB NUMBER:	W.O. NUMBER:	REVISIONS:	DATE:
PSC	3034.01 SLM	CLS	3034.01	A-264		8/13/04



LEGEND

- MONITORING WELL LOCATION
- SOIL BORING LOCATION
- UNITS = µg/L FOR TPH AS GASOLINE
- FORMER 550 GALLON UST'S
- * INDICATES OTHER CONSTITUENTS PRES IF TPH-GASOLINE IS NON-DETECT

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SITE PLAN WITH BORING LOCATIONS

TIPPLE MOTORS, INC.
524 MAIN STREET
FERNDALE, CALIFORNIA

PLATE: 2

DRAWN BY:	DWG NAME:	APPR. BY:	JOB NUMBER:	W.O. NUMBER:	REVISIONS:	DATE:
JLP	3034.01 SP	CLS	3034.01	A-609		6/22/05

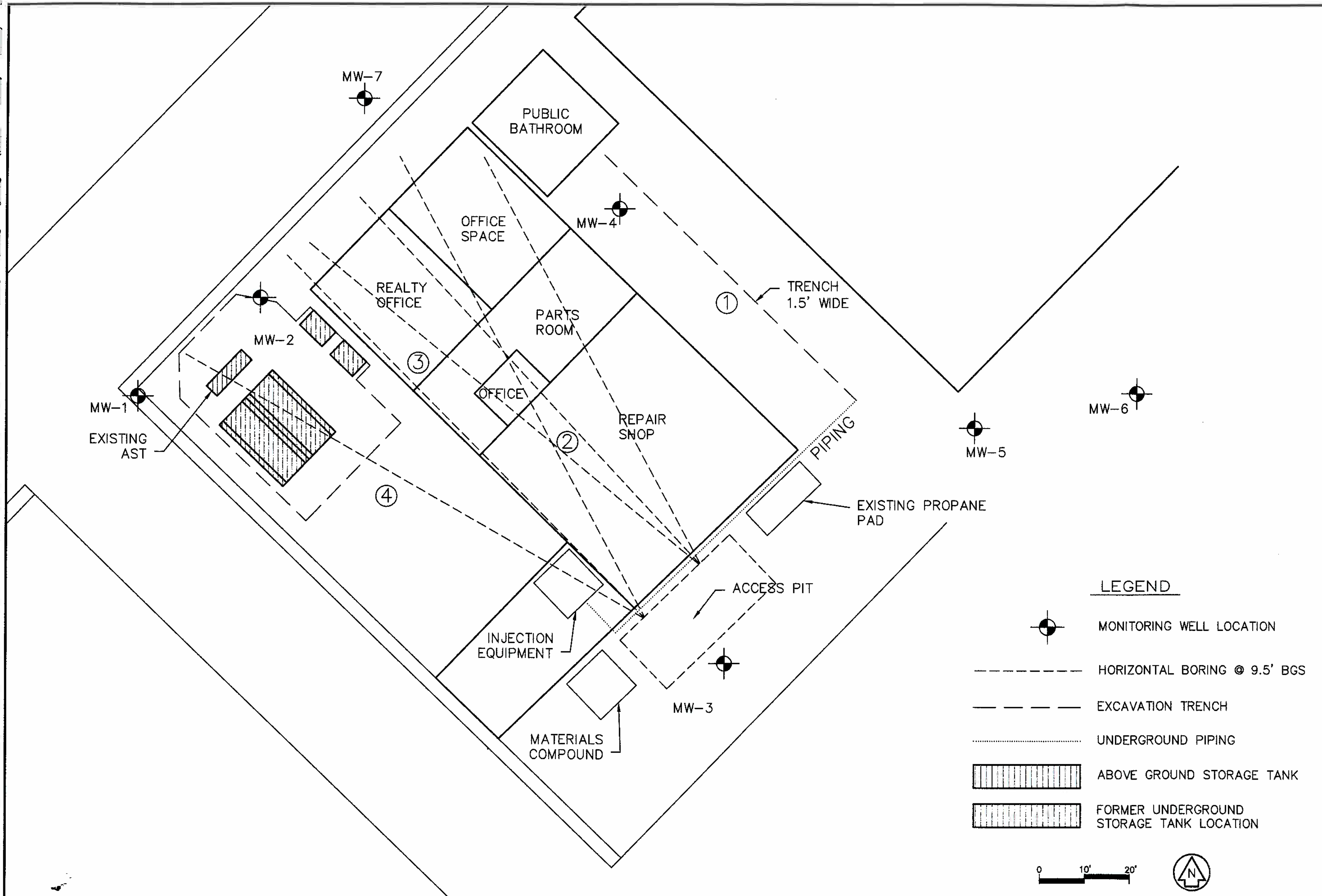

PLATE R-1

SITE PLAN
TIPPLE MOTORS, INC.
524 MAIN STREET
FERNDALE, CALIFORNIA

DRAWN: PSC

DATE: 6/22/05

JOB #: 3034.01

NO.	DATE	DESC

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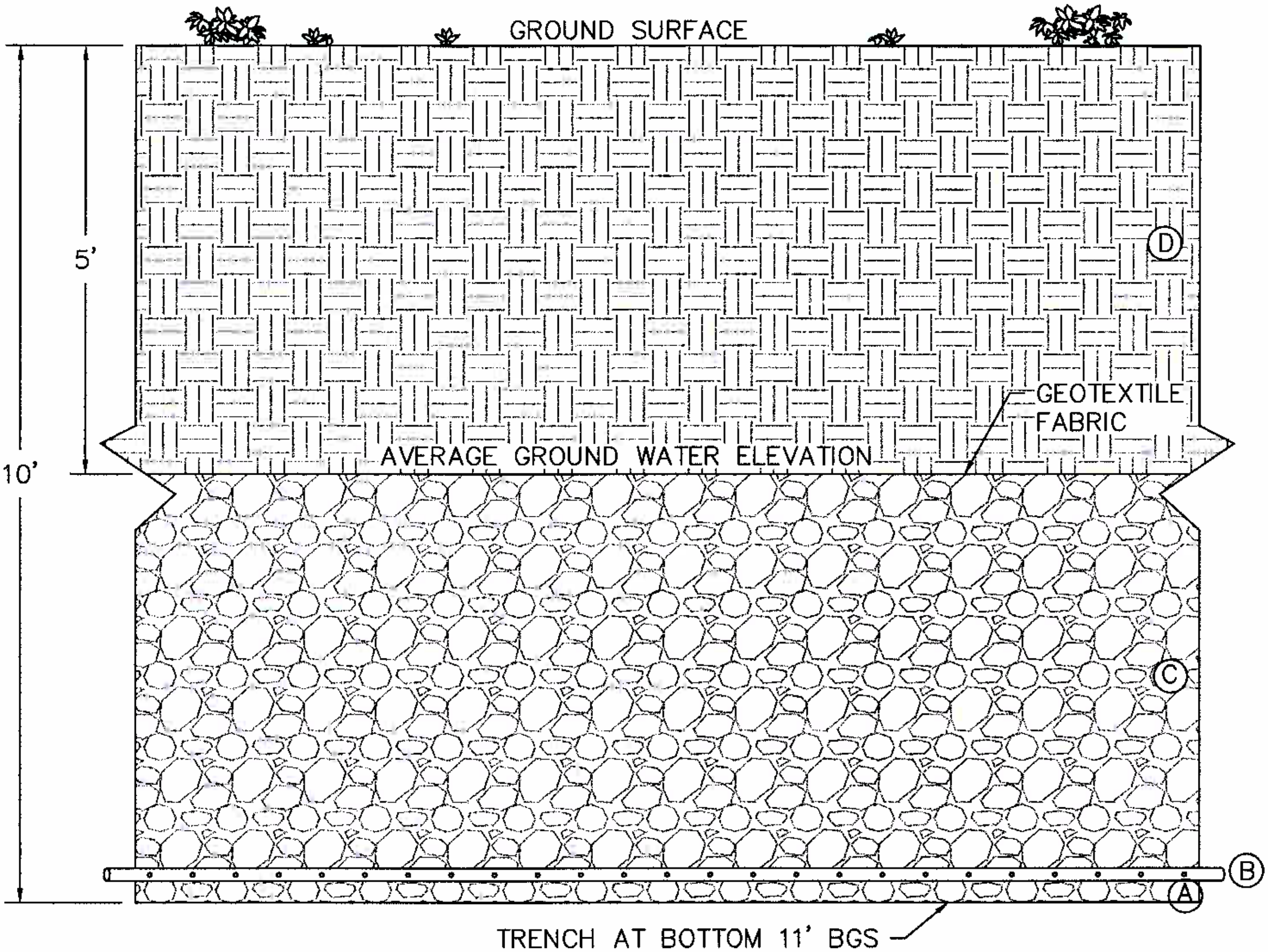
CROSS SECTION
REMEDIAL INJECTION TRENCH



(A) – 3" 3/8" WASHED PEA GRAVEL

(B) – 1 1/4"ø SCHEDULE 40 PVC INJECTION LINE WITH 9/16"ø HOLES ON 6" CENTERS

(C) – 5±' 3/8" WASHED PEA GRAVEL

(D) – COMPACTED (95%) CLEAN FILL SOIL

0' 1' 2'

SCALE: 1/2" = 1'

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CROSS SECTION

TIPPLE MOTORS
524 MAIN STREET
FERNDALE, CALIFORNIA

PLATE:
R-2

DRAWN BY:	DWG NAME:	APPR. BY:	JOB NUMBER:	W.O. NUMBER:	REVISIONS:	DATE:
JLP	3034.01 SP	BCW	3034.01	N/A		6/22/05